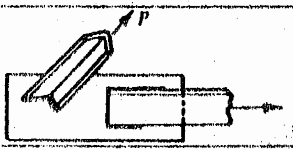
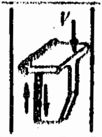
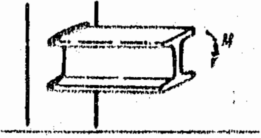
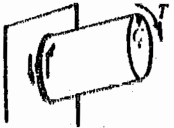
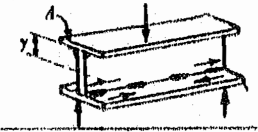
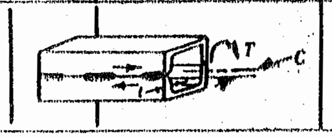
Type of Loading		**Standard Design Formula** **Stress**	**Treating the Weld as a Line** f
	Primary Welds transmit entire load		
	**tension or compression**	$s = \frac{P}{A}$	$f = \frac{P}{L_w}$
	**vertical shear**	$s = \frac{V}{A}$	$f = \frac{V}{L_w}$
	**bending**	$s = \frac{M}{Z}$	$f = \frac{M}{Z_w}$
	**twisting**	$s = \frac{TC}{J}$	$f = \frac{TC}{J_w}$
	Secondary Welds hold section together — low stress		
	**horizontal shear**	$s = \frac{VAy}{It}$	$f = \frac{VAy}{In}$
	**torsional horizontal shear**	$s = \frac{TC}{J}$	$f = \frac{TCt}{J}$

Primary Welds under Bending and Twisting:

Table (5) shows the properties of the weld schemes treated as a line forming the weld configuration with width = b and depth = d together with the position of the neutral axis X – X.

b, d, w
cg
Z_w
J_w

The table demonstrates:

- Section modulus (Z_w) for bending
- Polar moment of inertia (J_w) for torsion.

Procedure for working the weld size (w = weld leg):

(1) Find width (b) and depth (d) of the weld layout

(2) The section modulus (Z_w) given in the table are for maximum force at the top as well as the bottom portion of the welded connection.

(3) For unsymmetrical connections shown in this table, the maximum bending force is at the bottom.

(4) If there is more than one force applied to the weld, these are found and combined. All forces which are combined (vectorially added) must occure at the same position in the welded joint.

(5) Standard formula used for weld (treated as a line):

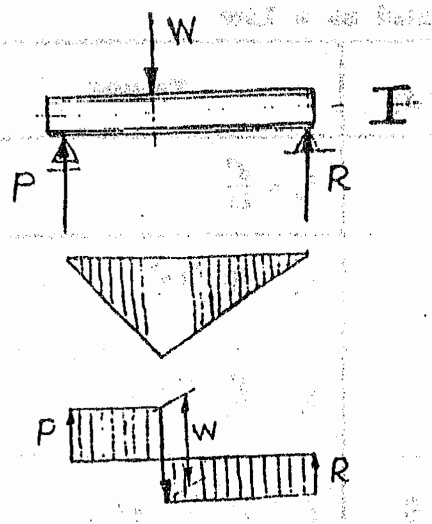
$$f = \frac{M_b}{Z_w} \quad (N/mm)$$

$$f^* = 0.707 \cdot \tau_{all\,weld} \cdot w \quad (N/mm) \quad \text{(See table 7)}$$

$$w = \text{weld leg size} = \frac{f}{0.707\,\tau_{all\,weld}} \quad (mm)$$

continuous w should be $\geq w_{min}$ given in table (3) or find $\frac{w}{w_{min}} \times 100\%$ and use table (10) to find length and [illegible] weld [illegible]

Calculation of Secondary Welds:



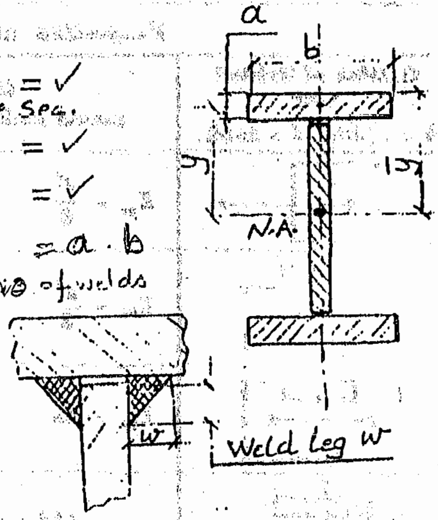
$I_{whole\ Sec.} = ✓$

$\bar{y} = ✓$

$y = ✓$

$A = a \cdot b$

n = No of welds



$$F_s = \frac{P.A.y}{I.n} \quad N/mm \;, \quad w = \frac{F_s}{0.707\ \tau_{all_{weld}}} \ mm, \text{where}$$

$\tau_{all_{weld}}$ is the value recommended by AWS as shown in table (7), w is then taken as % of w_{min} given in table (3) and from table (10) the welding style selected.

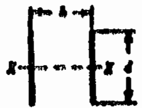
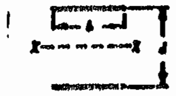
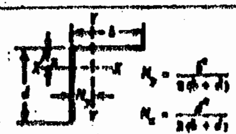
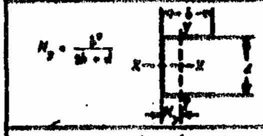
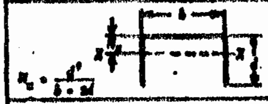
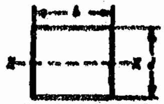
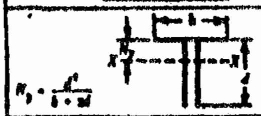
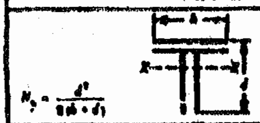
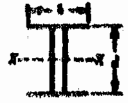
TABLE 3—Minimum Weld Sizes for Thick Plates (AWS)

THICKNESS OF THICKER PLATE JOINED t	t (mm)	MINIMUM LEG SIZE OF FILLET WELD ω	mm
to 1/2" incl.	up to 12.5	3/16"	5
over 1/2" thru 3/4"	From 12.5 up to 19	1/4"	6.5
over 3/4" thru 1 1/2"	19 up to 38	5/16"	8
over 1 1/2" thru 2 1/4"	38 up to 57	3/8"	9.5
over 2 1/4" thru 6"	57 up to 152	1/2"	12.5
over 6"	more than 152	5/8"	16

Minimum leg size need not exceed thickness of the thinner plate.

Table 5 – Primary Welds Treated as a LINE.

Properties of Weld Treated as a Line

Outline of Welded Joint b = width d = depth	Bending (about horizontal axis X-X)	Twisting
	$Z_w = \frac{d^2}{6}$	$J_w = \frac{d^3}{12}$
	$Z_w = \frac{d^2}{3}$	$J_w = \frac{d(3b^2+d^2)}{6}$
	$Z_w = bd$	$J_w = \frac{b^3+3bd^2}{6}$
	$Z_w = \frac{4bd+d^2}{6}$ top $= \frac{d^2(4bd+d)}{6(2b+d)}$ bottom	$J_w = \frac{(b+d)^4-6b^2d^2}{12(b+d)}$
	$Z_w = bd + \frac{d^2}{6}$	$J_w = \frac{(2b+d)^3}{12} - \frac{b^2(b+d)^2}{(2b+d)}$
	$Z_w = \frac{2bd+d^2}{3}$ top $= \frac{d^2(2b+d)}{3(b+d)}$ bottom	$J_w = \frac{(b+2d)^3}{12} - \frac{d^2(b+d)^2}{(b+2d)}$
	$Z_w = bd + \frac{d^2}{3}$	$J_w = \frac{(b+d)^3}{6}$
	$Z_w = \frac{2bd+d^2}{3}$ top $= \frac{d^2(2b+d)}{3(b+d)}$ bottom	$J_w = \frac{(b+2d)^3}{12} - \frac{d^2(b+d)^2}{(b+2d)}$
	$Z_w = \frac{4bd+d^2}{3}$ top $= \frac{4bd^2+d^3}{6b+3d}$ bottom	$J_w = \frac{d^3(4b+d)}{6(b+d)} + \frac{b^3}{6}$
	$Z_w = bd + \frac{d^2}{3}$	$J_w = \frac{b^3+3bd^2+d^3}{6}$
	$Z_w = 2bd + \frac{d^2}{3}$	$J_w = \frac{2b^3+6bd^2+d^3}{6}$
	$Z_w = \frac{\pi d^2}{4}$	$J_w = \frac{\pi d^3}{4}$
	$Z_w = \frac{\pi d^2}{2} + \pi D^2$	

Courtesy The Lincoln Electric Co.

TABLE 7—Allowables for Welds—Bridges (AWS Bridge)

Type of Weld	Stress	Steel	Electrode	Allowable
Complete-Penetration Groove Welds	tension compression shear	A7, A373	‡E60 or SAW-1	Same as [illegible]
		A36 ≦ 1" thick		
		A36 > 1" thick	‡E60 low-hydrogen or SAW-1	
		A441, A242*	E70 low-hydrogen or SAW-2	
Fillet Welds	shear on effective throat	A7, A373	‡E60 or SAW-1	τ = 12,400 psi or f = 8800 ω lb/in
		A36 ≦ 1" thick		
		A36 > 1" thick	‡E60 low-hydrogen or SAW-1	
		A441, A242*	E70 low-hydrogen or SAW-2	τ = 14,700 psi or f = 10,400 ω lb/in
Plug and Slot	shear on effective area	A7, A373, A36 ≦ 1" thick	‡E60 or SAW-1	12,400 psi
		A36 > 1" thick A441, A242*	‡E60 low-hydrogen or SAW-1	

* weldable A242
‡ E70 or SAW-2 could be used, but would not increase allowable

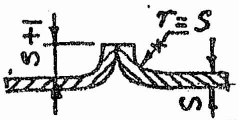
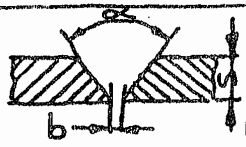
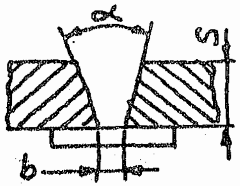
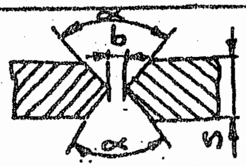
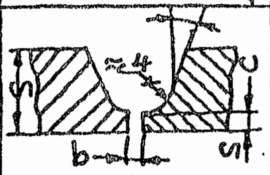
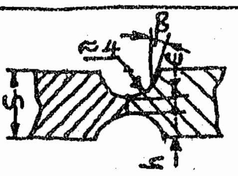
TABLE 10—Intermittent Welds
Length and Spacing

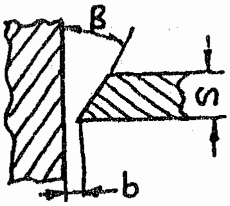
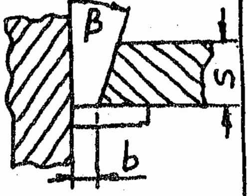
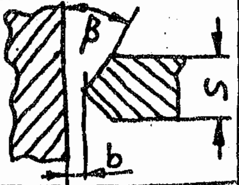
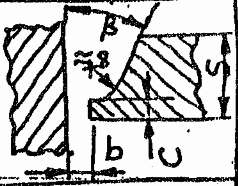
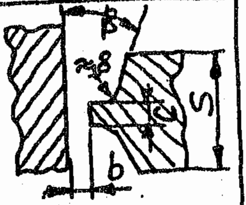
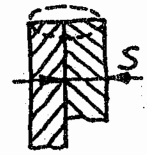
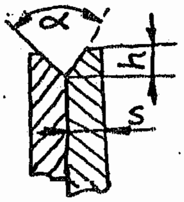
Continuous weld, %	Length of intermittent welds and distance between centers, in.		
75	. .	3-4	. .
66	. .	. .	4-6
60	. .	3-5	. .
57	. .	. .	4-7
50	2-4	3-6	4-8
44	. .	. .	4-9
43	. .	3-7	. .
40	2-5	. .	4-10
37	. .	3-8	. .
33	2-6	3-9	4-12
30	. .	3-10	. .
25	2-8	3-12	. .
20	2-10	. .	. .
16	2-12	. .	. .

12 cm

Extracted from DIN 8551 – Jan 1959

Edge preparation for open arc welding of steel by hand

No	S mm	Deposition method	Type of Weld	Symbol	Edge Form Sectional view	α or β degrees	Gap b(mm)	C mm	h mm
1	up to 2	From one side Only	Flanged butt weld	ʌ		—	—	—	—
2	3 5	One side Both sides	Square butt weld	II			≈ S ≈ S/2	— —	— —
3	3 to 20 5 to 20	One Side Two sides	Single Vee Butt Weld	V		≈ 60°	≈ 2	—	—
4	Over 10	From One Side (use back plate)	Double bevel Butt Weld	V		≈ 10°	6 to 10	—	—
5	From 16 – 40	From both Sides	Double Vee 2/3 Double Vee	X		≈ 60°	≈ 2	—	S/2 ≈ S/3
6	8 – 20	From both sides	Single Vee with root face	Y		≈ 60°	0 to 2	2 to 4	—
7	over 16	From One Side Only From both Sides	Single U	Y		≈ 10°	≈ 2 0 to 2	≈ 2 ≈ 3	— —
8	Over 30	From both Sides	Double U	X		≈ 10°	0 to 3	≈ 3	≈ S/2

Nº	S mm	Deposition method	Type of Weld	Symbol	Edge form Sectional view	α or β degrees	Gap b (mm)	C (mm)	h (mm)
9	3 to 16 6 to 16	From One Side From Both Sides	Half Single Vee	V		45° to 60°	0 to 3	—	—
10	Over 16	From One Side	Single-bevel			30° to 15°	6 to 10	—	—
11	16 to 40	From both sides	Double bevel	K		45° to 60°	0 to 2	—	—
12	Over 16	From One Side From both Sides	single J	μ		≈ 20°	≈ 2	≈ 2	—
13	Over 30	From both Sides	Double J	K		≈ 20°	≈ 2	≈ 2	—
14	Over 3	From One Side	Square edges	|||		—	—	—	—
15	Over 4	From One Side	Beveled edges	M		≈ 60°	—	—	5 to 1.2 S

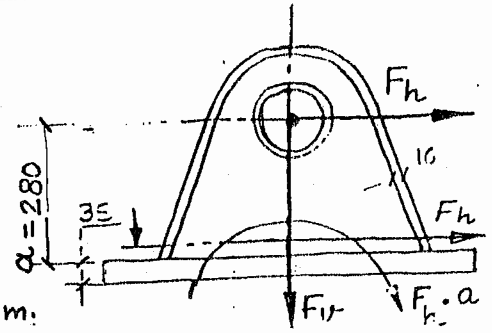
[illegible] 11[illegible] Mechanical Properties of Some Constructional Steels*

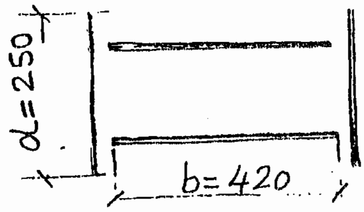
[illegible]	Thickness range, mm(in)	Yield point, min		Tensile strength		Elongation in 200 mm (8 in) min, %	Suitability for welding
		MPa	1,000 lb/in²	MPa	1,000lb/in²		
		Structural carbon-steel plates					
ASTM A[illegible]	All thicknesses	228	33	414–517	60–75	21	No
ASTM A[illegible]	To 100 mm (4 in), incl.	221	32	400–517	58–75	21	Yes
[illegible]	To 100 mm (4 in), incl.	248	36	400–552	58–80	20	Yes
		Low- and intermediate-tensile-strength carbon-steel plates					
ASTM A[illegible]	(structural quality)						
Grade [illegible]	All thicknesses	165	24	310	45	28	Yes
Grade B	All thicknesses	186	27	345	50	25	Yes
Grade C	All thicknesses	207	30	379	55	22	Yes
Grade D	All thicknesses	228	33	414	60	20	Yes
		Carbon-silicon steel plates for machine parts and general construction					
ASTM A284							
Grade A	To 305 mm (12 in)	172	25	345	50	25	Yes
Grade B	To 305 mm (12 in)	159	23	379	55	23	Yes
Grade C	To 305 mm (12 in)	145	21	414	60	21	Yes
Grade D	To 200 mm (8 in)	145	21	414	60	21	Yes
		Carbon-steel pressure-vessel plates					
ASTM A285							
Grade A	To 50 mm (2 in)	165	24	303–379	44–55	27	Yes
Grade B	To 50 mm (2 in)	186	27	345–414	50–60	25	Yes
Grade C	To 50 mm (2 in)	207	30	379–448	55–65	23	Yes
		Structural steel for locomotives and cars					
ASTM A113							
Grade A	All thicknesses	228	33	414–496	60–72	21	No
Grade B	All thicknesses	186	27	345–427	50–62	24	No
Grade C	All thicknesses	179	26	331–400	48–58	26	No
		Structural steel for ships					
ASTM A131							
Grade A	To 13 mm (½ in)						
Grade B	To 25 mm (1 in)						
Grade [illegible]	To 50 mm (2 in)	221	32	400–490	58–71	21	No
Grade E	To 50 mm(2 in)						
Grade CS	To 50 mm (2 in)						
Grade [illegible]	To 50 mm (2 in)						
		High-strength low-alloy steel plates					
ASTM A24[illegible]	To 19 mm (¾ in), incl.	345	50	485	70 min	18	Yes
ASTM A4[illegible]	Over 19 to 38 mm (¾ to 1½ in), incl.	315	46	460	67 min	18	No
ASTM A[illegible]	Over 38 to 102 mm (1½ to 4 in), incl.	290	42	435	63 min	18	Yes
ASTM A[illegible]8	[illegible] to 102 mm (4 in), incl.	345	50	485	70	18	Yes

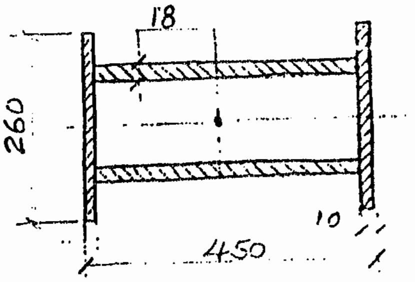
Primary Weld

Example:

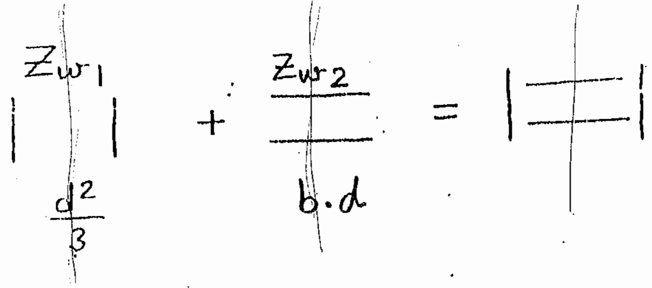
$F_v = 1254$ kN
$F_h = 151.5$ kN
$a = 280$ mm
$\therefore M_k = 151.5 * 280$ N.m.







Lines of welds.



fv = b

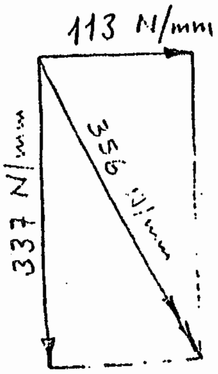
$$f_{bending} = \frac{151.5 * 280 * 1000}{\frac{250^2}{3} + (420 * 250)} = 337 \text{ N/mm}$$

$$f_{shear} = \frac{151.5 * 1000}{2(420 + 250)} = 113 \text{ N/mm}$$

$$f_{resultant} = \sqrt{(337)^2 + (113)^2} = 356 \text{ N/mm}$$

$$f^* = 0.707\, \tau_{all\,weld} \cdot w$$

$$w = \frac{356}{0.707 * 85} = 4.2 \text{ mm}$$



Parent metals: 35 max, 10 mm min.

$\therefore w_{min} \geq 8$ mm < 10 mm.

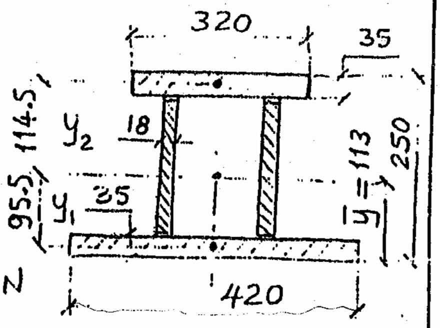
Continuous weld Leg = 8 mm.

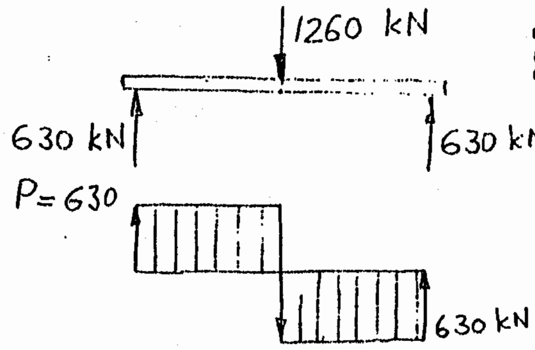
Secondary Weld:

Example: Sec. X–X in drawing $^{D}_{3}$ (see sec. 6)

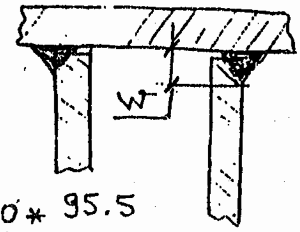
$A_1 = 420 * 35 = 14700 \ mm^2$

$A_2 = 320 * 35 = 11200 \ mm^2$





$I = 315 * 10^6 \ mm^4$



No of welds = 2

$$F_{S_1} = \frac{P \cdot A_1 \cdot y_1}{I \cdot n} = \frac{630000 * 14700 * 95.5}{315 * 10^6 * 2}$$

$$= 1.40 * 10^3 \ N/mm$$

Table 7

$$\tau_{all\ weld} = 12\,400 \ psi = 85.50 \ N/mm^2$$

$$\therefore w_1 = \frac{1400}{0.707 * 25,50} = 23 \ mm \quad \text{Web thickness}$$

Use Welding electrode. E 70 or SAW2 without Changing $\tau_{all.} = 85,50 \ N/mm^2$

→ If No of welds = 4 , $w_1 = 12$ mm.

Also:

$$F_{S_2} = \frac{630000 * 11200 * 114.5}{3.15 * 10^6 * 2} = 128 * 10^3 \ N/mm$$

$$w_1 = \frac{128000}{0.707 * 8550} = 21 \ mm > \text{Web thickness}$$

→ Note: if $\tau_{all_{weld}} = 101,36 \ N/mm^2$ (E60 or SAW1):

$$\therefore w_1 = \frac{1400}{0.707 * 101,36} = 19.5 \ mm$$

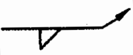
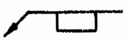
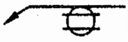
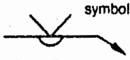
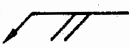
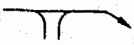
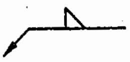
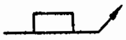
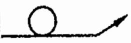
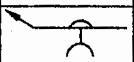
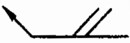
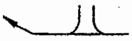
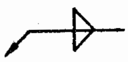
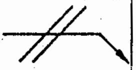
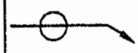
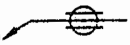
$$\& \quad w_2 = \frac{1220}{0.707 * 101,36} = 18 \ mm$$

*The section X-X in strength calculations was found to be highly stressed and its hight was changed to 300 mm

Table 14-1

AMERICAN WELDING SOCIETY

Basic Welding Symbols and Their Location Significance

Location Significance	Fillet	Plug or Slot	Spot or Projection	Seam	Back or Backing	Surfacing	Scarf for Brazed Joint	Flange Edge
Arrow Side					Groove weld symbol 			
Other Side					 Groove weld symbol	Not used		
Both Sides		Not used	Not used	Not used	Not used	Not used		Not used
No Arrow Side or Other Side Significance	Not used	Not used			Not used	Not used	Not used	Not used

Supplementary Symbols Used with Welding Symbols

Convex Contour Symbol

Convex contour symbol indicates face of weld to be finished to convex contour

Finish symbol (user's standard) indicates method of obtaining specified contour but not degree of finish

Weld-All-Around Symbol

Weld-all-around symbol indicates that weld extends completely around the joint

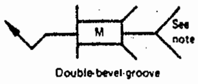
Joint with Backing

With groove weld symbol

Note: Material and dimensions of backing as specified

Joint with Spacer

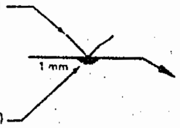
With modified groove weld symbol



Note: Material and dimensions of spacer as specified

Melt-Thru Symbol

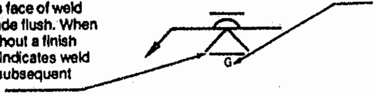
Any applicable weld symbol



Melt-thru symbol is not dimensioned (except height)

Flush Contour Symbol

Flush contour symbol indicates face of weld to be made flush. When used without a finish symbol, indicates weld without subsequent finishing



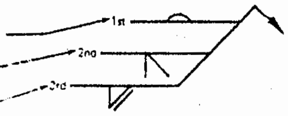
Finish symbol (user's standard) indicates method of obtaining specified contour but not degree of finish

Multiple Reference Lines

First operation shown on reference line nearest arrow

Second operation, or supplementary data

Third operation, or test information

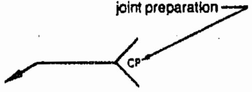


Field Weld Symbol

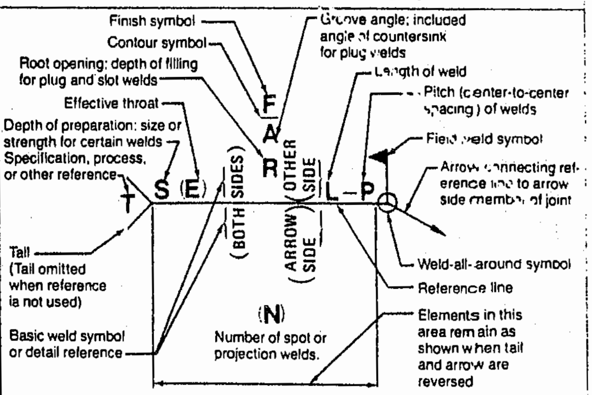
Field Weld symbol indicates that weld is to be made at a place other than that of initial construction

Complete Penetration

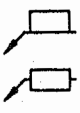
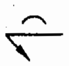
Indicates complete penetration regardless of type of weld or joint preparation



Location of Elements of a Welding Symbol

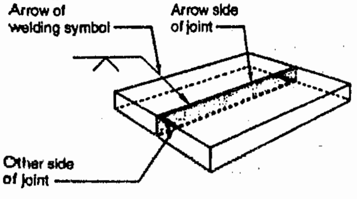


Supplementary Symbols

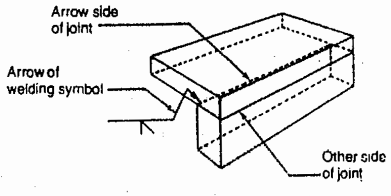
Weld-All-Around	Field Weld	Melt-Thru	Backing, Spacer	Contour		
				Flush	Convex	Concave
						

Basic Joints—Identification of Arrow Side and Other Side of Joint

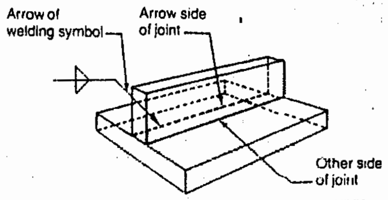
Butt Joint



Corner Joint

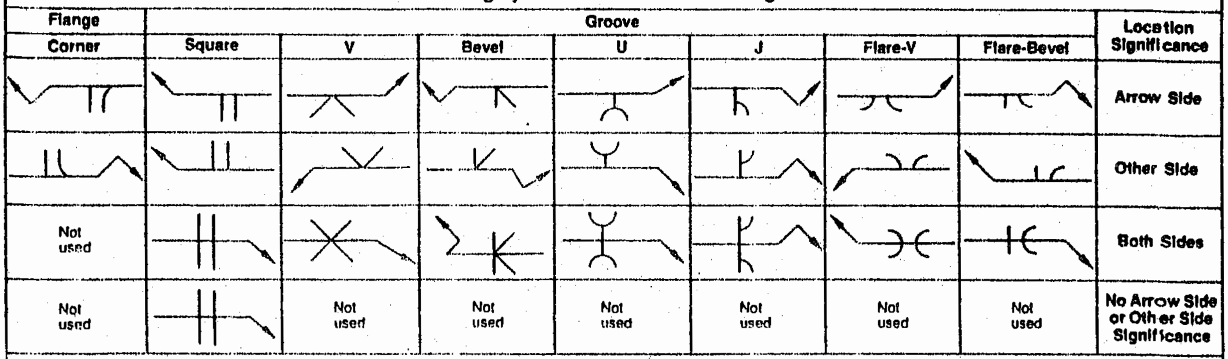


T-Joint



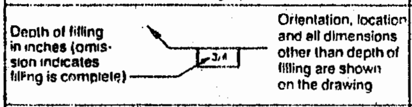
STANDARD WELDING SYMBOLS

Basic Welding Symbols and Their Location Significance



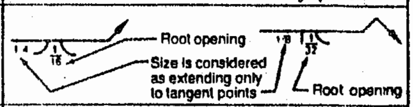
Typical Welding Symbols

Slot Welding Symbol

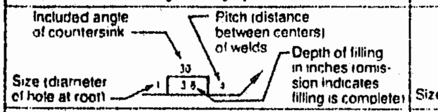


Square-Groove Welding Symbol

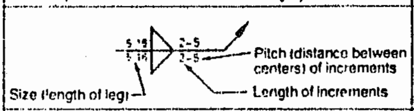
Flare-V and Flare-Bevel-Groove Welding Symbols



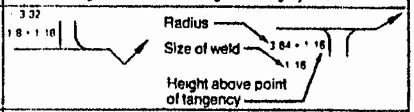
Plug Welding Symbol



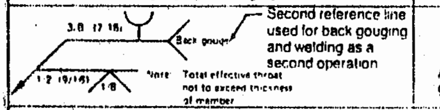
Chain Intermittent Fillet Welding Symbol



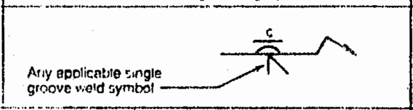
Edge- and Corner- Flange Welding Symbols



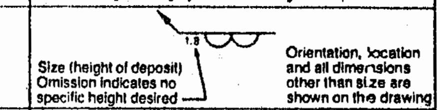
Backgouging Welding Symbol



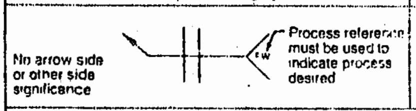
Back or Backing Welding Symbol



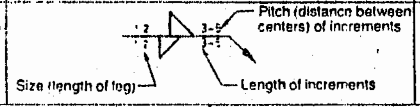
Surfacing Welding Symbol Indicating Built-up Surface



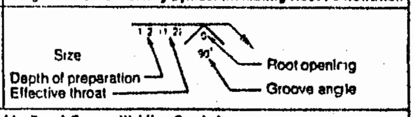
Flash or Upset Welding Symbol



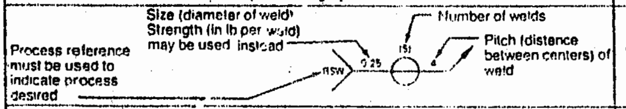
Staggered Intermittent Fillet Welding Symbol



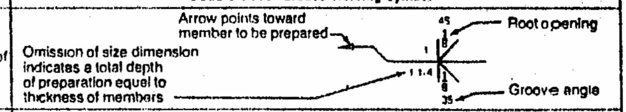
Single-V Groove Welding Symbol Indicating Root Penetration



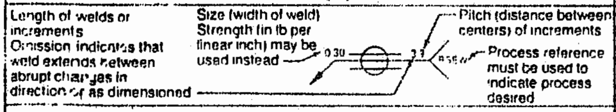
Spot Welding Symbol



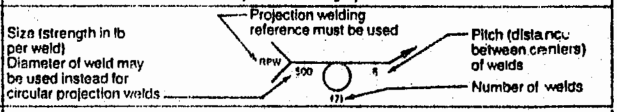
Double-Bevel-Groove Welding Symbol



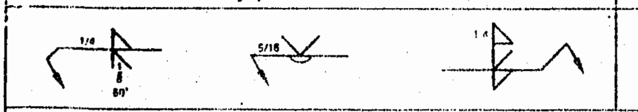
Seam Welding Symbol



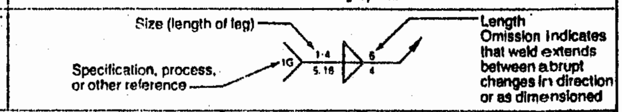
Projection Welding Symbol



Welding Symbols for Combined Welds

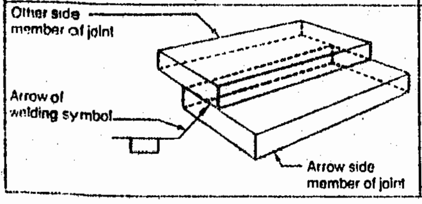


Double-Fillet Welding Symbol

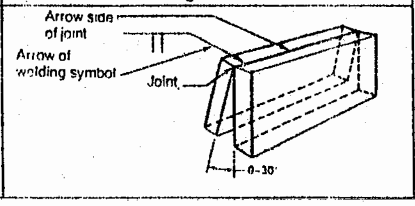


Basic Joints--Identification of Arrow Side and Other Side of Joint

Lap Joint



Edge Joint



Process Abbreviations

Where process abbreviations are to be included in the tail of the welding symbol, reference is made to Table A, Designation of Welding and Allied Processes by Letters, of AWS 2.4-79, 71.

A2.1-79

AMERICAN WELDING SOCIETY, INC.
2501 N.W. 7th Street, Miami, Florida 33125